Cretaceous-Tertiary History of the Salt River Region, an Analogue for the Geomorphic History of the Grand Canyon Region

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The geology of the Salt River region of east central Arizona provides constraints on the development of the southern Colorado Plateau boundary during the Late Cretaceous, Tertiary, and Quaternary Periods. Unlike the Grand Canyon region, the geologically analogous Salt River region 300 km to the southeast contains a relatively complete Late Cretaceous-Recent geologic record of its tectonic and geomorphic history. In this paper, I discuss some problems with understanding the origin of Grand Canyon and Colorado River, provide the basis for comparison between the Grand Canyon region and the Salt River region, and relate relevant elements of Salt River geologic history based on work completed to date. I hypothesize that the location of Grand Canyon may be controlled by topographic features inherited from the Laramide period and that the Kaibab uplift may have been incised by an ancestral northeast flowing river which predated the uplift. Once a canyon was incised, the river's course was reversed during the late Tertiary by uplift of the Colorado Plateau/Rocky Mountain region and Tertiary foundering of the Basin and Range. This hypothesis provides an alternative mechanism for how the later Colorado River was able to establish its course across the earlier-formed Kaibab uplift.

An enigma of the Colorado River is: how did a southwest-flowing river system emplace itself on a system of northeast dipping structures? This is not unique to the Grand Canyon section. It occurs along much of the Green and Colorado Rivers from the Uinta Basin to the southern edge of the Colorado Plateau (Hunt 1969). The Colorado Plateau dips gently to the northeast and is punctuated with numerous E-NE-dipping monoclines (Huntoon 1990). The S-SW-flowing Colorado River and its major tributaries commonly bisect these structures resulting in an apparent lack of structural control of the present river drainage system.

The Grand Canyon and Salt River regions occupy the same tectonic setting and share similar structural and stratigraphic histories. Both regions:

a) have major southwest-flowing river systems that cross the southern boundary of the Colorado Plateau province into the Basin and Range province.
b) bisect a monocline-bounded Laramide uplift (Huntoon 1990, Davis et al. 1982).
c) are characterized by generally flat-lying Late Proterozoic and Paleozoic strata (Reynolds 1988).
d) exhibit a gentle regional northeast dip to the strata.
e) contain evidence for northeast-flowing Tertiary streams that originated south of the Colorado Plateau and flowed NE onto the Colorado Plateau from the southerly Mogollon Highlands.
f) have early Tertiary river sediments that occupy paleocanyons and/or are distributed across a broadly beveled erosion surface of increasingly older rocks toward the southwest.
g) experienced a regional drainage reversal during the Tertiary (Potochnik 1989, Young 1982).

The Salt River crosses the east-dipping Canyon Creek monocline/fault, which is on strike with the East Kaibab monocline 250 km to the north. Both are basement-cored uplifts. The Canyon Creek structure bounds the eastern flank of the Laramide Apache uplift in the same way that the East Kaibab structure bounds the eastern flank of the Laramide Kaibab uplift. Today, the Apache uplift is bisected by the southwest-flowing Salt River and the Kaibab uplift is bisected by the southwest-flowing Colorado River. Unlike the Grand Canyon area, however, the Salt River Canyon area contains remarkably well-preserved Cretaceous through Tertiary geologic record (Potochnik 1989, Potochnik in prep.).

Between the northeast corner of Arizona and southern edge of the Transition Zone in eastern Arizona, the Late Cretaceous marine sequence overlies a beveled erosion surface of increasing older rocks to the south ranging from Upper Jurassic to Carboniferous in age (Dickinson et al. 1989). Rejuvenated stripping of this Early Cretaceous erosion surface continued during Laramide northeast tilting of the eastern Transition Zone. This resulted in a widespread Eocene erosion surface that beveled Upper Cretaceous strata and earlier-formed monoclines (Potochnik 1989) across the ancestral Mogollon highlands.

During the early Tertiary, a northeast-flowing Laramide stream, here named the Apache River, cut a 1000 to 1400 m deep canyon into the Paleozoic and Proterozoic rocks of the Apache uplift (H.W. Peirce 1982 pers. comm., Faulds 1988, Potochnik and Faulds 1998). Apache River lag gravels were deposited in the bottom of this paleocanyon. East of the Canyon Creek fault, up to 375 m of alluvial plain of gravel and sand called the Mogollon Rim Fm. was dispersed to the E-NE on the Eocene erosion surface (Potochnik 1989).

During the Oligocene to Early Miocene, the paleocanyon was partly filled with 260 meters of locally-derived gravel, sand, and minor limestone called the Whitetail Conglomerate. Aggradation was caused by incipient down to the west reactivation of the Canyon Creek fault (Faulds 1986), which blocked the transport of most sediment, locally ponded the river, but apparently did not prevent the flow of water to the east-northeast. East of the Canyon Creek fault, the regional NE drainage was deflected by the reactivation of NW-trending faults and by volcanism in the Mogollon-Datil field to the SE near the New Mexico-Arizona border (Potochnik 1989).

West of the Canyon Creek fault, the Whitetail Cgl. is conformably overlain by a sequence of ash flow tuff, gravels, and lava flows up to 115 meters in thickness (Faulds 1988). This volcanic-gravel sequence, which ranges from 18.6 to 14.8 Ma, caused further drainage disruption and ponding in the Salt River paleocanyon (Faulds 1988, Potochnik and Faulds 1998). There does not appear to be a hiatus in paleocanyon deposition until after emplacement of the 14.8 Ma Black Mesa basalt (Potochnik and Faulds 1998). A strongly developed petrocalcic horizon, which commonly caps the Whitetail Cgl. and Mogollon Rim Fm. throughout the region, may represent a period of time during which drainages were not integrated.

Regional drainage reversal is signaled by the cutting of a valley up to 164 m deep into the 375 m Whitetail Cgl. and volcanic sequence. This ancestral Salt River flowed in the opposite direction to the Apache River that had carved the paleocanyon. This valley was subsequently filled and aggraded with up to 420 m of Dagger Canyon conglomerate (Potochnik and Faulds 1998). The net result was a 1400 m deep early Tertiary paleocanyon filled with 764 m of Tertiary gravels and volcanic rocks. This would be analogous to filling the Grand Canyon with gravels at Lava Falls Rapid to the level of the Esplanade surface near Toroweap Point.

The modern Salt River has incised through most of the 764 m of Tertiary deposits in the Salt River paleocanyon nearly to its original Laramide bedrock depth. This excavation is complete at the eastern boundary of the Apache uplift, but an undetermined thickness of Tertiary paleocanyon fill remains in the paleocanyon to the west, where early Tertiary geology is obscured by the northwest-striking Tonto Basin half-graben (Faulds 1988).

Similarly, In the Grand Canyon vicinity deep Laramide paleocanyons were cut into underlying Paleozoic rocks along the Colorado Plateau southern boundary during the Late Cretaceous and early Tertiary Periods (Young 1982). A Tertiary sequence comprising the Music Mountain fm., Hindu fanglomerate, West Water fm., Buck and Doe cgl., Peach Spring Tuff, basalt flows, and Coyote Spring fm. aggraded in these paleocanyons. Tributaries of the Colorado River have incised and excavated much of this paleocanyon fill in the same way as the Salt River.

The Salt River and Colorado River occupy the same geotectonic setting and share an analogous pre-Pliocene geologic history. Salt River geology shows that the current southwest drainage system originated after 14.8 Ma. The Colorado River became the master drainage from the Rocky Mountains during the late Tertiary. The Salt River became a tributary to the Colorado River, with much of its early Tertiary geologic section preserved intact. The path of the Colorado River across the southern Colorado Plateau was probably dictated by the most opportune path for Lake Hopi to overflow toward the foundering Mogollon Highlands that lay to the south. Although partly infilled by Tertiary rocks, the position of Laramide paleocanyons probably influenced the paths of late Tertiary river systems on the southern boundary of the Colorado Plateau. The Colorado River may have simply inhabited a pre-existing Laramide paleocanyon, established by Laramide structures. This hypothesis counters the peneplain concept, first proposed by Powell and Dutton, for establishment of the Colorado River drainage through the Grand Canyon district.

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